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on

THE ECONOMIC ASPECTS OF CURRENT LARCH SAWFLY INJURY TO TAMARACK

Prepared by

MINNESOTA DEPARTMENT OF AGRICULTURE
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In Association With

DEPARTMENT OF CONSERVATION
Minnesota Forest Service

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FOREST INDUSTRIES

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TABLE OF CONTENTS

INTRODUCTION

The subject matter of this report represents the collective efforts of groups in the Lake States and Canada, which have a stake in the tamarack resources of our two countries. Like most problems of this kind, there is no simple solution because the problem itself has never been clearly delineated. This conference arose out of a desire to sharpen the focus of entomologists, in particular, who are charged with making recommendations for alleviating the threat to tamarack. Foresters, too, expressed interest years ago in management and utilization of this relatively minor species. The sum total of the remarks presented at this conference represents some of the best information available on tamarack and on the larch sawfly. It marks a significant step forward in the progress of foresters, entomologists, and processors and consumers of wood products, in their efforts to collaborate for better preservation and utilization of our forest resources.

In his introductory remarks, T. L. Aamodt, Director of the Division of Plant Industry, and State Entomologist, underscored his desire to employ the facilities of his organization for maximum effectiveness in solving forest insect problems. He also called attention to the uniquely successful coordination that has always existed in Minnesota in regard to problems involving more than one administrative unit. At the same time, the larch sawfly problem was cited as an illustration of the interdependence of each and every group concerned, if a satisfactory solution is to be arrived at. In conclusion, Mr. Aamodt called for a strengthening of the University's capacity to do research in this field, and invited all participating groups to avail themselves freely of the resources of the State Entomologist's Office in attempting to deal with insect and disease problems wherever they occur.

The contributions to the program are listed in the order in which they were presented at the conference. The arrangement seemed logical in prospect, and since the pre-eminence of any particular subject on this program is dependent to a large extent upon individual interest, no useful purpose would be served by overediting the manuscript. For the most part, the material is presented as it was offered at the conference. In a few instances, where abstracts were not submitted, only the editor's summary of the presentation is included here.

Acknowledgement is made of cooperation given by M. B. Dickerman, Director, Lake States Forest Experiment Station, U. S. Department of Agriculture; Charles B. Eaton, Entomologist in Charge, Forest Insect Laboratory, U. S. Department of Agriculture; A. C. Hodson, Professor of Entomology, University of Minnesota; F. H. Kaufert, Director, School of Forestry, University of Minnesota; and Clarence Prout, Director, Division of Forestry, Minnesota Department of Conservation, for their encouragement and suggestions in carrying out this undertaking. Finally, thanks are due all participants for their willingness to communicate their special knowledge to the group.

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OUTLINING THE PROBLEM

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Before World War II, our attitude toward the control of forest defoliators by spraying while short of despair, was far from optimistic. In most cases, the cost was considered prohibitive and the probability of obtaining good results was viewed with grave doubt. The prevention of devastating outbreaks by proper forest management was projected as the best solution for the future, while control by climatic factors and natural enemies offered the best, but by no means a completely satisfactory solution at the moment.

Now, though the prevention of insect outbreaks by forest management still is considered a feasible and worthwhile goal, it is possible to take immediate direct action by other means. Fortunately, there has been a rapid evolution in insect control methods which involves the coincidental development of new insecticides and much more effective methods of dispersing concentrated insecticides. The availability of chemicals like DDT and airplanes equipped to spray large areas cheaply has changed the entire picture. There no longer is any doubt as to our ability to control many forest defoliating insects satisfactorily and economically. This does not mean that when and wherever an insect pest becomes numerous, that one should consider the wholesale spraying of infested areas always as a necessary or even a desirable move. Quite often the most important decision that must be made is whether to spray or not to spray, even when there is no doubt that the control operation would be effective.

It is the purpose of this conference to draw out answers to the question of the need and practicality of attempting to control the larch sawfly in Lake States tamarack stands. Of first importance is the need for information concerning the abundance, value, and current and future demand for tamarack which will establish the importance of this species as an economic asset; and from this to determine whether protection from the larch sawfly seems to be justified. If economic justification for sawfly control is indicated by the value of the crop, the threat of damage by the sawfly must be weighed against the cost of control. Should there be no question of the economic advantage of protection, the feasibility of any control measure must be assured beyond any reasonable doubt. Answers to questions such as these are essential, before a program of immediate control of the current outbreak and future protection of growing stock can be incorporated into a well integrated management plan for tamarack. It is hoped that this conference will provide many, if not all, of the answers we seek.

NATIONAL FOREST TAMARACK HOLDINGS IN MINNESOTA

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The Timber Management section of the U. S. Forest Service Regional Office is inclined to be optimistic about tamarack as a commercial species, providing available stands can be brought into production. Its unit value as pulpwood, mine timber, and piling should ultimately equal, if not exceed, that of jack pine.

National Forest tamarack holdings, total volume and annual growth by size classes are shown in the following tables:

Tamarack Area in Acres by Size Classes

	Seedlings & Saplings	Poles	Sawtimber	Total
Chippewa N.F.	6,054	10,467	68	16,589
Superior N.F.	13,287	4,156	—	17,443
Total	19,341	14,623	68	34,032

Tamarack Volume in Cords by Size Classes

	Seedlings & Saplings	Poles	Sawtimber	Total
Chippewa N.F.	21,248	130,330	412	151,990
Superior N.F.	39,861	49,123	----	88,984
Total	61,109	179,453	412	240,974

Tamarack Annual Growth in Cords by Size Classes

	Seedlings & Saplings	Poles	Sawtimber	Total
Chippewa N.F.	2,100	3,670	10	5,780
Superior N.F.	3,900	1,250	—	5,150
Total	6,000	4,920	10	10,930

Present Market Value

1. Ceiling price per cord - $16.00 per cord rough
   $21.00 per cord peeled
2. Average stumpage value - $2.00 per cord rough
3. Average stumpage value piling - 10¢ per lineal foot
4. Average stumpage value mine timbers - $8.00 per M

It can be seen that National Forest tamarack holdings in Minnesota are quite small, particularly in the larger size classes. Nevertheless, the U. S. Forest Service is concerned about the approximately 2,400,000 cords in Minnesota and is interested in measures that will insure its merchantibility. If tamarack becomes available in quantity, a price of $40.00 a cord at the mill seems not unreasonable. Despite the small area under National Forest management, the U. S. Forest Service regards with interest whatever steps may be taken to protect what might potentially represent a $100,000,000 resource in the Lake States.

COMPARISON OF THE SUPPLY OF TAMARACK WITH OTHER LAKE STATES SPECIES

Arthur G. Horn
Forest Economist 1/
Lake States Forest Experiment Station

Regionally the current supply of tamarack as compared to other Lake States species can be estimated only from data based on an initial field survey made in the years 1934-1936 and corrected and brought up-to-date by bookkeeping methods. More up-to-date field data are being collected and will be presented in the form of state-wide analytical reports in another year or two. However, current statistics are available on the tamarack resource of a number of northern Minnesota counties based on recent field data collected by the Office of Iron Range Resources and Rehabilitation, with assistance from other state, federal, and private agencies.

Forest Lands and Timber Types

Minnesota, Wisconsin, and Michigan have a total land area of approximately 123 million acres. Of this total land area, about 55 million acres is forest land. Only 50 million acres of the present forest area, however, is available for commercial use. The other 5 million acres includes area not capable of producing timber of commercial quantity and quality and those withdrawn from commercial use for parks, preserves, and wilderness areas.

The 50 million acres of commercial forest land is made up of 12 recognized major forest types. The aspen type occupies the largest acreage, representing about 40% of the commercial forest area. Some of the other more extensive types are the spruce swamp, spruce-fir, jack pine, and northern hardwoods. The tamarack type occupies sites similar to those of black spruce, but it is less extensive.

The botanical range of tamarack extends from Canada through New England and the Lake States, and as far south as the northern part of West Virginia. Its range in the Lake States extends through most sections of Wisconsin and Michigan and about one-half of Minnesota. In Minnesota it is limited almost entirely to that area east of an imaginary line drawn from the northwest corner to the southeast corner of the state. Although tamarack covers a smaller proportion of the state of Minnesota, the acreage here is larger than that of Wisconsin and Michigan combined. Forest Surveys show that the tamarack type occupies about 1,600,000 acres in the Lake States. Minnesota has about 1,000,000 acres of tamarack and Wisconsin and Michigan each have about 300,000 acres.

Size Classes

Of the 1,600,000 acres of tamarack in the Lake States, only about 30,000 acres is classed as sawtimber. The sawtimber areas are characterized by stands of timber with 1,500 board feet net or more per acre in trees 9.0 inches or larger in diameter at breast height. According to Forest Survey figures, about 20,000 acres of tamarack sawtimber occur in Minnesota, and only about 10,000 acres in Michigan. Wisconsin's acreage of tamarack sawtimber is negligible.

About 300,000 acres, or approximately 19% of the total tamarack acreage, is

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1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota, University Farm, St. Paul, Minn.

classed as pole timber in the region. These pole timber stands are characterized by stands at least 10% stocked (interpreted as meaning not less than three cords net per acre in trees 5.0 inches or more in diameter) and with not more than 1,500 board feet net per acre in trees 9 inches or larger in diameter at breast height. In Minnesota, such stands total about 150,000 acres. Michigan and Wisconsin have 120,000 acres and 30,000 acres respectively.

Seedling and sapling stands make up about 440,000 acres, or about 28% of the total tamarack acreage in the region. The seedling and sapling stands contain less than 3 cords, or 1,500 board feet net per acre, but with sufficient trees predominantly below 5.0 inches in diameter at breast height to occupy at least 40% of the growing space (50 saplings or 200 seedlings per acre). Seedling and sapling stands comprise about 270,000 acres in Minnesota. Wisconsin has about 90,000 acres and Michigan 80,000 acres.

The remaining 830,000 acres of tamarack is composed of poorly stocked or understocked stands. Tamarack stands of this size class comprise over one-half the total tamarack acreage in the Lake States. Such areas are defined as previously timbered lands including grass and brush areas which now contain less than 3 cords, or 1,500 board feet net per acre approximately 10% stocked or insufficient trees under 5.0 inches in diameter to be considered 40% stocked. Over one-half million acres of poorly stocked or understocked tamarack stands occur in Minnesota. Fairly large acreages of this size class also occur in the other two states with about 180,000 acres in Wisconsin and 90,000 acres in Michigan.

Timber Volume

The total volume of merchantable timber on commercial forest land in the Lake States is about 20 billion cubic feet. This excludes such secondary material as limbwood of hardwood trees and cull trees.

The present volume of sawtimber amounts to about 40 billion board feet. About one-third of the total board-foot volume is softwoods. Michigan has the largest volume of softwood sawtimber and Wisconsin the least.

A breakdown by species shows that hemlock is the most abundant softwood sawtimber species in the region, with a volume of 3.9 billion board feet. Tamarack is the least important, with only 200 million board feet, much of it unavailable for immediate use because of poor location and scattered occurrence.

The merchantable cordwood volume, which is defined as material below sawlog size, amounts to about 13.5 billion cubic feet (180 million cords) in the Lake States. About 30% of the cordwood is made up of softwood species. The most abundant softwood species below sawtimber size is balsam fir, with a volume of 800 million cubic feet, or 10.6 million cords. Tamarack, along with white pine and red pine, is a minor species. The cordwood volume of tamarack amounts to approximately 370 million cubic feet, or 4,900,000 cords. Only white and red pine have less cordwood volume. Minnesota has the largest cordwood volume of tamarack with 2,400,000 cords, Michigan ranks second with 1,700,000 cords, and Wisconsin third with 800,000 cords.

Growth

The net cubic-foot growth of all trees 5 inches or more is estimated at about 720 million cubic feet in the Lake States. Total growth of the hardwood species amounts to about 540 million cubic feet annually, compared to a total annual growth of 180 million cubic feet for the softwoods. Taking all size classes into consideration, the net cubic-foot growth of all trees 5 inches or more in diameter at breast height is equivalent to about 14 cubic feet per acre.

Accurate growth figures for the tamarack type on a regional or state level are lacking. The 1934-1936 survey figures show that the net annual growth of all size classes in the tamarack type averaged about 9 cubic feet per acre. A low growth rate in this timber type is plausible because much of the tamarack is found growing in swamps and bogs in a semi-stagnant condition. Many stands at the time had poor stocking and a high percentage of unmerchantable timber (trees less than 5 inches); also high mortality and cull losses occurred each year. Some stands of tamarack timber classed as unmerchantable because of size in the original survey have reached merchantable size with the result that the average growth rate has increased for the type. Recent Forest Survey figures by individual counties will probably bear out this point.

A Brief Review of Recent Forest Survey Data in Northern Minnesota

The inventory and growth phase of the Forest Survey has been completed in the Central Pine and Red River Valley Districts of Minnesota. Survey findings show that the tamarack type covers 226,700 acres in these 19 counties. The Central Pine District includes 8 counties and contains 205,700 acres of tamarack, while the 11 counties of the Red River Valley District have only 21,000 acres. The tamarack acreage and volume figures for each of these 19 counties are as follows:

Tamarack Acreage and Volume by Counties

County	Area	Unpeeled Volume
	Acres	Cords
Itasca	38,600	244,700
Aitkin	39,400	215,300
Crow Wing	10,400	51,600
Cass	39,100	394,400
Wadena	1,500	1/ 11,900
Hubbard	3,900	1/ 48,100
Beltrami	64,400	136,400
Clearwater	8,400	104,700
Central Pine District	205,700	1,207,100
Roseau	17,300	1/ 76,000
Kittson	—	—
Marshall	500	1/ 2,000
Pennington	—	—
Red Lake	—	—
Polk	1,400	1/ 7,000
Mahnomen	1,800	1/ 8,000
Norman	—	—
Clay	—	—
Wilkin	—	—
Traverse	—	—
Red River Valley District	21,000	93,000

1/ Preliminary volume figures, subject to change.

None of the 226,700 acres of tamarack in the Two Minnesota districts qualified as large sawtimber. Only 2,600 acres were classed as small sawtimber. Pole timber is the largest single size class comprising 121,500 acres, or about 54% of total tamarack type. Seedling and sapling stands comprise 102,600 acres of which 81,000 acres is satisfactorily stocked and 21,600 acres is poorly stocked.

The total merchantable volume of tamarack timber in these two areas is approximately 1,300,000 standard cords, with an average volume per acre of 5.7 cords. The average volume per acre in small sawtimber stands is 15 cords; pole timber, 8.7 cords; seedling and sapling stands with good stocking, 2.4 cords; and seedling and sapling stands with poor stocking, 1.2 cords per acre. About 80% of the net volume for all size classes is comprised of tamarack; other species, such as spruce, balsam fir, white cedar, aspen, etc., make up the remaining 20%.

Survey findings further show that in these 19 Minnesota counties, most of the present growth is accumulating on immature stands of tamarack timber. Total growth in the poorly stocked sawtimber stands is 82% of a cord per acre. No data are available for the good and medium-stocked stands. Growth for pole timber by stocking classes is as follows:

Good - 40% of a cord per acre
Medium - 34% of a cord per acre
Poor - 41% of a cord per acre

In the restocking class, growth per acre is 41% of a cord per acre in the well-stocked stands; 22% of a cord in the medium-stocked stands; and 5% of a cord in the poorly-stocked stands.

A substantial volume of the growth is made up of ingrowth; that is, new volume from 4 inch trees moving from an unmerchantable to a merchantable status. The ingrowth amounts to approximately 19% of a cord per acre in small sawtimber stands; about 22% of a cord per acre in pole timber; and 20% of a cord in the restocking class.

Changes in Forest Conditions Since 1936

The new survey has not progressed far enough to offer more than a general appraisal of the changes that have taken place in Minnesota's tamarack since the 1936 survey, but the following trends seem clear:

1. A substantial increase in pole-timber area. Saplings have moved into pole size during the interim.
2. A reduction in area of seedlings and saplings.
3. Improved density of stocking in the seedling, sapling, and pole stands.
4. Generally higher volumes per acre of cordwood material.
5. Increase in the average annual growth rate of cordwood volume.
6. A decrease in the total volume cut.

TAMARACK ON STATE LAND – STAND QUALITY, AND MARKET VALUE

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Forest statistics for the Lake States brought up to date by the Lake States Experiment Station in 1945 estimates that in Minnesota 980,000 acres, or 5.9% of the commercial forest lands are occupied by tamarack type with an estimated volume of 100 million board feet of merchantable timber. Over half of the tamarack acreage, or 550,000 acres is considered as poorly stocked or denuded. Seedlings and saplings comprise 270,000 acres, or about 27%; pole timber 150,000 acres, or 15%; and sawtimber but 20,000 acres, or 2% of the remaining productive area.

Recent surveys are providing more up-to-date data on the tamarack type, but as yet, a considerable portion of the state has not been covered. This fact makes it possible only to indicate trends from available data. Iron Range Resources and Rehabilitation county survey reports covering some 5,478,000 acres of forest land, place 169,300 acres, or about 3% of the total in tamarack type.

State owned forest lands total somewhat over 4,100,000 acres. The Division of Forestry to date has completed an inventory of 1,742,000 acres for management purposes. Therefore, complete figures covering the total acreage of tamarack type occurring on state land are not available. Of the area inventoried, about 6.6%, or 114,331 acres were typed as productive tamarack lands. Most of these state lands lie in the large swamp areas which might influence the percentage of land in tamarack, but it seems reasonable to conclude that somewhere between 225,000 and 250,000 acres will be classified as productive tamarack type when the inventory is completed. There is also a large acreage of stagnant tamarack in the big bog areas of northern Minnesota. However, in our forest survey, we summarize the non-productive types as a unit, so an acreage figure for stagnant tamarack cannot be quoted. Roughly 20% to 25% of the area inventoried has been classified as non-productive land.

A summary by size class of the tamarack acreage on state lands indicates that only 3% of the tamarack on state lands is in the 9 inch – 15 inch size class, while 43% is restocking and 54% is pole sized timber. These percentages compare quite favorably with those obtained from the Iron Range survey. It is apparent that there is a lack of balance in tamarack size class distribution. This is also true insofar as distribution by density class is concerned because 61% of all merchantable stands classified were of poor density. Medium and good density stands occupied 25% and 14% of the tamarack type respectively. It is assumed that this same relationship would apply to the tamarack types covered by the county surveys.

In spite of the lack of balance for ideal management in the data just presented, our survey does show a considerable volume of tamarack on state lands. The total tamarack volume from all types in a summary of 10 survey units is estimated to be 665,000 cords and 29,500 M.B.F. The tamarack management policy is to grow mining timber products on all sites capable of doing so. The larger sized trees produced in this type of management would, of course, have several market possibilities if the mines cannot consume the supply. Pulpwood will come primarily from poor sites so far removed from the mines that the cutting of mining poles would not be profitable. Some thinnings would yield pulpwood. It can be seen from this management policy that a considerable volume in the 5 inch – 9 inch stands will not be ready for harvest for some time.

During the 1930's, large tamarack mining timber operations were still common, but at the present time it appears that the sawlog stands with sufficient volume to support similar operations no longer exist. Operations involving tamarack sawlog timber are now carried out on a reduced scale, or the tamarack is cut as a part of a more diversified operation. Because of the large area of poorly stocked sawlog stands, much of the present sawlog or mining timber volume will be difficult if not impossible to harvest. This is particularly true where tamarack is growing as a scattered overstory to stagnant cedar or brush which is a condition commonly found on state lands. In addition to the low volume yields of tamarack, the distance from the mines to the present tamarack area is also an important factor in reducing the harvest possibilities of much of the present sawlog type. However, in those stands in which it is a component species, comparatively low volume per acre tamarack yields are being successfully logged through a combined pulpwood and/or mining timber operation with spruce pulpwood. The large acreage and cordwood volume in the present 5 inch - 9 inch class presages a somewhat better situation in the not too distant future if the stands are not killed in the present larch sawfly epidemic.

There is not too much information available on the market value of tamarack products in dollars and cents. However, an analysis of the tamarack products cut on state lands for the past eight years shows that mining timber and poles and ties apparently find a ready market in Minnesota's iron mines, although in the past ten or twelve years, the trend has been towards a decreased overall demand from the mines for these products. It is estimated that about 75% of the mining needs for large sized tamarack products are supplied from sales of state timber. The average annual sales of tamarack from state lands since 1943 have been 511,000 board feet, and 1,034,134 lineal feet of mining timber and 15,012 ties. The average annual income to the state has been $7,333 from these sales. It is encouraging to note that there is an increasing interest in tamarack as a pulp wood. It is hoped that this interest will soon develop into a steady demand for tamarack for this use. This would make it possible to harvest some of the stands that now offer a poor logging chance for sawlogs, but which with the better utilization of pulpwood operations would increase the yield and make a more profitable operation. The present cut of tamarack in cords is discouragingly low when the total wood available is considered, although there is a trend toward an increase. It is assumed that the increase is due to the use of tamarack as pulpwood, which is apparently the key to the value of tamarack from a goodly portion of the low volume state lands.

CONSUMPTION AND UTILIZATION OF TAMARACK BY FOREST INDUSTRIES OF THE LAKE STATES

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In surveying the forest resource of this region, the Lake States Forest Experiment Station obtains information not only on present timber supplies and growth, but also on drain. Data on wood requirements are obtained from annual or periodic reports from the primary wood-using industries, covering, in some cases,

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the receipts of sawlogs and bolts at the plants or the year's production of finished products. From these figures the Station computes commodity drain; that is, the amount of live merchantable timber removed through cutting, including logging waste, during the year.

Forest Industries in the Lake States

According to recent surveys, there are about 6,000 primary wood-using plants in the Lake States. There are some 5,400 sawmills, of which 35 are large, 165 are medium, and 5,200 are small. Other wood-using plants consuming logs and bolts include 49 pulp mills, 85 veneer mills, 8 excelsior plants, 7 cooperage mills, 3 wood distillation plants, and 448 miscellaneous plants (shingle, lath, bowling pin, woodenware, and crate manufacturers). Wisconsin plants consume a larger volume of logs and bolts than either Minnesota or Michigan plants.

Lumber

Annual Lake States lumber production dropped quite steadily from approximately 10 billion board feet to about 430 million board feet between 1890 and 1932. Tamarack lumber made up but a small part of this total.

In 1899, when it was first recorded separately, about 6 million board feet of tamarack lumber was produced in the Lake States. Cutting of tamarack logs for local mills increased steadily, reaching a maximum of 155 million board feet in 1909. The cut of tamarack declined in the years that followed, and in 1932 reached an all-time low of about 1½ million board feet. Since 1932, the cut of tamarack for lumber has averaged about 3 million board feet. The current rate is approximately 4 million board feet, including boxboards and railroad cross ties. Minnesota mills account for about 60% of the production, Wisconsin 30%, and Michigan 10%.

About 95% of the tamarack lumber is cut by small portable-type sawmills. The annual output of each of these small mills is usually less than 200 thousand board feet. They are moved from one locality to another as the occasion demands.

Pulpwood

The decline of the lumber industry has been partially offset by the development of an increasingly important pulp and paper industry. Pulpwood consumed by Lake States mills has increased from less than 500,000 cords in 1904 to 2,800,000 cords in 1950. The increased consumption of wood has drained heavily on the timber resource of the region. In 1932, about 1,000,000 cords of pulpwood were harvested in the Lake States. The cut has been steadily increasing, and reached levels of over 2,000,000 cords in the late 1940's. To augment the growing shortage of long-fibered woods, greater use is being made of shorter-fibered species, especially aspen, which now ranks as one of the principal pulpwood species in the Lake States. Some mills are drawing wood from other regions, notably the Rocky Mountain region, to meet current requirements.

In spite of local wood shortages of softwood species, the use of tamarack for pulpwood has not increased. Over a ten or fifteen year period, the consumption of tamarack for pulpwood has never exceeded 50,000 cords during any one year. During the past five years, consumption of tamarack dropped from 26,000 cords in 1947, to a low of 1,600 cords in 1950. Of the 49 pulp mills operating in the Lake States, only 3 or 4 use tamarack. Although tamarack can be reduced

to paper by the sulphate process or by the ground-wood process, the species has never been widely accepted by the industry.

Wood for the Iron Ore and Copper Mines

Wood requirements for Lake States mines have been heavy during the past ten-year period. Open-pit and underground mines have been operating at or near full capacity.

Wood requirements of open-pit and underground mines differ in that open-pit mines use mostly sawed material such as timbers, planking, lumber, etc., while the underground mines, in addition to using sawed material, also use large quantities of round or split materials, commonly referred to as mine timbers, cribbing, poles, and lagging. Much of the wood consumed by local mines is procured locally.

It is estimated that approximately 7,600,000 cubic feet of round and split mine products of all species were cut by Lake States timber operators in 1950. Of the 7,600,000 cubic feet produced, Michigan accounted for approximately 63% of the total, Minnesota 32%, and Wisconsin 5%.

Operators of mines consider tamarack as one of the better species. Nearly 2½ million cubic feet of round and split tamarack were produced for local mines in 1950. Minnesota mines use as much tamarack as the Michigan and Wisconsin mines combined. Greater use of tamarack in this state is probably attributed to the fact that there is a larger available supply. Mine poles account for about 60% of the total tamarack consumption. The remaining 40% is comprised almost entirely of mine timbers, cribbing, and lagging.

Other Products

Tamarack is also cut for such products as fuel wood, fence posts, utility poles, piling, cabin logs and bolts, shingles, and lath. In some of the agricultural areas, small volumes of tamarack are used in the round for straw sheds, corncribs, and as stakes for supporting grapevines and raspberry bushes. Of these products, fuel wood and fence posts are the most important.

Fuel wood production, including all species and classes of material, is estimated at about 4½ million cords in the region. About two-thirds of this amount is cut from nonmerchantable material such as tops and limbs from logging operations, dead and cull trees, noncommercial species, small trees, etc. The annual cut of tamarack for fuel wood is estimated roughly at about 250,000 cords, representing about 6% of the total. About 190,000 cords or three-fourths of the tamarack fuel wood is cut in Minnesota. The use of fuel wood is declining each year, as more and more families convert to other types of fuel. As long as a high farm income level prevails, there is very little likelihood that the production of this commodity will be increased.

An estimated 26 million posts were cut on farms and commercial logging operations in 1950. The farm-cut posts were mostly made up of hardwood species. The commercial cuttings were mostly cedar with smaller proportions of tamarack, jack pine, and aspen. The number of tamarack posts produced amounted to about 700,000 pieces in 1950, nearly one-half of them in Minnesota.

On the basis of studies by the University of Minnesota and U. S. Forest Service, a post-peeling plant was established at Cass Lake, Minnesota, in 1949. Recently, a treating plant has been added. The operation furnishes full or part-time employment to more than 100 woods workers. Abundant raw material

for fence posts is available on the Chippewa National Forest and other nearby forest lands in the form of overstocked jack and red pine stands. Several attempts have been made to use tamarack as fence-post material at a pilot operation; however, the results have been rather disappointing. Tamarack has good form and peels easily. The stumbling block, however, has been the inability to get sufficient penetration with chemical wood preservatives.

Value of Tamarack Products to Producers

Tamarack products in the Lake States had an estimated value to the producer of about 4 million dollars in 1950. The fuel wood value was the highest, amounting to approximately 3 million dollars. Round and split materials for the mines were second with about $700,000. Pulpwood was the least with only $25,000. Fence posts and other minor products made up the balance. The processed value of these same products would be considerably more than the above figures.

Timber Drain

The production of rough forest products is an important aspect of drain. To it must be added the amount of wood left in the woods as logging waste to get at the net volume of timber removed from the growing stock on commercial forest lands through cutting.

Total timber drain of all species from cutting in the Lake States, including tops of conifers, amounted to an estimated 555 million cubic feet in 1950. About 270 million cubic feet (1,300,000,000 board feet) or 49% of the total drain was from sawtimber trees (over 9 inches in diameter at breast height for conifers, or 11 inches in diameter at breast height for hardwoods) and 285 million cubic feet, or 51% from pole timber trees (between 5 inches in diameter at breast height and sawtimber size). There seems to be a definite trend toward use of smaller timber not only for pulpwood and box bolts, but also for lumber.

The cutting drain on tamarack in the region amounted to about 6,200,000 cubic feet in 1950. About 3½ million cubic feet (12½ million board feet), or 56% of the total tamarack drain was from sawtimber trees and 2,700,000 cubic feet, or 44% from pole timber trees. Minnesota accounted for nearly 70% of the total tamarack drain. Wisconsin was second and Michigan third, with 16% and 14%, respectively.

Fuel wood was the largest single tamarack drain item in the region. In 1950, fuel wood made up 15% of the sawlog drain, and 45% of the total cubic-foot drain. Mine timbers including other round and split wood materials for local mines ranked second, accounting for over 50% of the sawlog and 30% of the cubic-foot drain. Logs and bolts cut for lumber, boxboards, and railroad cross ties ranked third, accounting for 25% of the sawlog and 15% of the cubic-foot drain. Fence posts, pulpwood, hewn ties, and other miscellaneous forest products accounted for the remaining 10% of sawlog and cubic-foot drain.

Cutting Versus Supply

Accurate allowable-cut figures are not available for tamarack, so it is difficult to make a comparison of drain versus the portion of the present growing stock that should be removed. However, recent forest surveys completed in northern Minnesota counties show that, in general, the current rate of cutting in the tamarack type should be stepped up.

As in most timber types in the Lake States, the cut of merchantable tamarack has been heavy in the accessible areas. Conversely, scattered tracts of tamarack in the more remote areas are undercut, and in some cases timber is going to waste.

Any serious outbreaks of disease or insects causing heavy mortality would further aggravate the condition and demand increased utilization of the species to prevent excessive waste.

As mentioned earlier, large volumes of tamarack were consumed by Lake States plants during the early 1900's. Following the last large outbreak of the larch sawfly which occurred in 1909 or thereabouts, the cut of tamarack sawlogs dwindled to a relatively small figure. During the past several decades, the cut of tamarack has largely been limited to remnant stands that escaped the ravages of the larch sawfly and other forest enemies. Even some of these stands are unavailable for immediate use because of poor location and scattered occurrence.

Tamarack stands of today are largely nonmerchantable because of small tree size. Because of the preponderance of small timber, industry has been unable to fully utilize the resource. However, some stands are growing from the unmerchantable into merchantable status. If our tamarack timber is able to survive and grow for a few decades to large pole-timber or small sawtimber size, the demand for tamarack products doubtless will increase, and the species will again regain greater prominence as a Lake States timber species.

USE OF TAMARACK IN THE MINING INDUSTRY 1/

Editor's note: John Steinke, of the Oliver Mining Company, discussed the use of tamarack by the mining industry. It was pointed out that tamarack is a desirable species in the industry, and that the Oliver Mining Company could use up to 5,000 cords of tamarack per year, if available. Use of other species could be eliminated altogether if tamarack were available in larger sized sticks.

USE OF TAMARACK FOR FENCE POSTS 1/

Editor's note: John F. Neetzel, of the Lake States Forest Experiment Station, stressed the strength and durability aspects of tamarack when converted to fence posts. Its use has been limited however, by the inadequacy of existing methods of applying preservative.

1/ Abstract of presentation not available at time of printing.

CURRENT CONSUMPTION AND UTILIZATION OF TAMARACK FOR PULPWOOD

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My remarks on the use and possible use of tamarack for pulpwood will be largely confined to the past and potential consumption of the species by the Minnesota and Ontario Paper Company mills at International Falls, Minnesota, and to the supply situation existing in the area from which this Company obtains most of its pulpwood. There are two reasons why I will confine my remarks to this territory. First, because I have a great deal more information about this area than about the situation in the rest of the State, and secondly, because the large swamp areas of Koochiching County and adjacent counties contain a high proportion of tamarack swamps supporting stands of pulpwood size at the present time. The larch sawfly epidemic during the years 1910 and 1911 virtually wiped out most of the tamarack stands in this locality and they are just now recovering from this severe attack and reaching pulpwood size. The threat of the elimination of tamarack from these areas again and the possible necessity for a large scale salvage program presents a very real problem in this territory.

In the five management districts from which the Minnesota and Ontario Paper Company obtains between 60% and 65% of its pulpwood there is a productive forest area of about 2,100,000 acres in all ownerships, but predominantly State. On over 100,000 acres in this general territory, tamarack, largely in immature or pole size stands, is the predominant type. The estimate for these tamarack stands shows 422,000 cords of pulpwood size. The State of Minnesota holds most of these tamarack lands through the medium of swamp land grants by the Federal Government at about the turn of the century so that the State has the largest stake in the problem of larch sawfly control.

The annual allowable cut of tamarack has been set at 12,000 cords. However, the allowable cut figure has never been reached, even though much tamarack has been produced in the area for special products such as mining timber, piling and ties. The total drain for all tamarack products, including pulpwood, from State lands during the 1950-51 season was only 2,000 cords. During the year 1951, 4,000 cords of tamarack pulpwood was used by the Kraft mill of the Minnesota and Ontario Paper Company at International Falls with a ten year average consumption of about 2,000 cords. The principal reason for this low consumption is because tamarack has been cut, on going operations, only as it has been encountered. Except for a few mining timber jobs there has been no great effort made to open up any areas for tamarack production exclusively. To open up for logging the large acreage of tamarack for salvage operation over the short period of a few years would be a herculean task, even if it were possible for the market to absorb the large cordage which would be produced. Tamarack stands are widely scattered, and generally grow in deep peat swamps in very isolated localities in which winter penetration is the only method of reaching such stands. It would, therefore, seem that a large scale salvaging operation would be prohibitively expensive from a logging standpoint. By the same token, it is recognized that any control measures would likewise be expensive because of the scattered nature of the tamarack stands, and because in many instances, tamarack and black spruce grow in mixtures over considerable areas. Present management policies in this territory are aimed at eventually opening up and establishing permanent logging operations throughout so that emergency salvage could be readily handled, but the program has not been advanced far enough to help, except in a few instances, at the present time.

In the territory under discussion, the larch sawfly was first observed on a few scattered trees in the summer of 1947. It has spread rapidly during the past four years, until during the summer of 1951 some infestation was observed in all tamarack areas throughout the region. Actual defoliation has been more severe in some localities than in others, but it appears as though unless some control measures are undertaken within a year or two that many of the young tamarack stands will be destroyed.

In recognizing that there may be a tamarack salvage problem in Minnesota, we are also faced with the fact that the larch sawfly epidemic seems to be developing on the Canadian side of the boundary concurrently, and there may be considerable pressure to salvage tamarack there also.

From all standpoints, as a pulpwood, tamarack when used in the sulphate process in the production of bleached Kraft papers is the equal of, or slightly higher in yield than is jack pine, which is almost universally used for this type of pulpwood in the Lake States. Its use as a pulpwood, however, is confined largely to the sulphate, or Kraft process because it is insoluble in acids, and therefore, cannot be readily used for sulphite pulp. In any alkaline process, it is acceptable if it can be produced at a cost which is the equivalent of the cost of jack pine.

It would appear, therefore, that the limiting factors in stepping up the consumption and utilization of tamarack, were this to become necessary because of the further spread of the larch sawfly, would be (1) the capacity of mills currently making bleached Kraft pulp to expand their use of tamarack through substituting it for jack pine, which has been the mainstay in Kraft pulping for many years, and (2) the ability of pulpwood loggers to produce this wood at a cost equivalent to that of jack pine.

The prospective utilization for tamarack pulpwood is quite limited, there being only two mills, the Minnesota and Ontario Paper Company, and the Northwest Paper Company in Minnesota, and three mills of any size in Wisconsin which could use any appreciable amount of this type of wood. Even if all these mills were to substitute 100% tamarack for jack pine, which could hardly be done, it would appear that only a small part of any pulpwood size stands of tamarack could be salvaged. With recently established bleaching facilities at International Falls, we expect to gradually step up our consumption of tamarack to 10 to 12,000 cords per year, which should largely take care of the allowable cut of this species. To have to increase this consumption to this level or beyond immediately, is not desirable or practical.

From a logging standpoint, the comparative location of jack pine and tamarack stands would almost preclude the possibility that tamarack could be logged as cheaply as jack pine and in many areas it is certain that the cost would be prohibitively high.

It would appear from the above facts that were a wholesale killing of our stands of tamarack to take place, that only a small percentage of them could be salvaged, and used, and that the balance would be a complete loss. Even the use of dry tamarack for fuelwood, formerly a brisk market, has dwindled away.

It would therefore seem that a more primising program of action would be an immediate attempt to arrest and control the ravages of the insect before the point of destruction is reached.

THE BIOLOGY OF TAMARACK AND ITS MANAGEMENT

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Tamarack is a pioneer species invading areas not previously occupied by trees; it is not capable of coming in beneath an overstory. This is the result of its great intolerance of competition, particularly competition for light. On the other hand, the species is very tolerant of oxygen deficiency at the root zone, and consequently often occurs, at least in the southern portion of its range, in swamps or bogs. Near the northern limits of its natural range, it occurs on upland sites, as it may even near its southern limits if freed of competition. Since in Minnesota, it is largely confined to very wet sites, it often occupies land which can produce little more than tamarack.

The age class distribution of tamarack in the Lake States is very roughly indicated by the following 1950 data published by the Lake States Forest Experiment Station:

Sawtimber size	30,000 acres
Pole timber size	300,000 acres
Seedling and sapling size	440,000 acres
Poorly stocked	830,000 acres

To obtain more specific age class data, 28 stands of sapling and pole size were sampled to determine age, the results being shown in Table I. most tamarack stands are essentially even-aged, although the range of ages may extend over 20 to 30 years; at least a few stands and perhaps a good many contain two age classes, a light overstory of older trees with the major portion of the stand in a younger age class beneath.

TABLE I

Age Class Distribution
In Sapling and Pole Sized Tamarack Stands

Principal Age Class Years	Number of Stands
20	6
30	2
40	4
50	0
60	4
70	6
80	2
90	0
100	3
110	0
120	0
130	0
140	1

With more than half of the tamarack acreage in the Lake States classified as poorly stocked, reproduction obviously is a problem. Therefore, harvesting should not be undertaken in existing stands without giving regeneration serious attention. Study of the reproduction biology of the species during 1948, 1949, and 1950 has provided fundamental information against which reproduction cuttings may be planned.

Good crops of seed in tamarack are produced at intervals of approximately four years. Although isolated trees may produce cones as early as 15 years of age, seed production in moderately well-stocked stands does not begin until about age 40. Maximum per acre production takes place in more or less open stands between the ages of 50 and 150. In all stands, dominants with well-developed crowns produce most prolifically, suppressed trees yielding very few cones.

In some years, as many as half of the seeds in three-quarters of the cones may be destroyed by a cone insect. Squirrels and birds are of less importance but cause limited loss before the seeds have matured.

About 80% of the seeds are normally disseminated in September in central Minnesota, most of the remaining filled seeds falling in October. Tamarack is a prolific seed producer, yielding as many as five million seeds per acre in a bumper year in a more or less open stand. Heavier stands in the same year may produce only one to two million seeds per acre. If the subsequent season is favorable, one million seeds will produce desirable stocking at the end of the first year. Dissemination in quantity sufficient for satisfactory restocking, extends to a distance equal to one to two times tree height.

Rodents may be an important factor in seed destruction following dissemination, causing about 50% loss on areas studied. Loss may be particularly severe on exposed mineral soil where 75% of the seeds were destroyed on the areas studied. Better germination on such sites partially offsets rodent losses.

Germination in the field was found to be only 4% or 5% of the seeds disseminated, although under favorable laboratory conditions, germination approached 75% to 80%. Exposed sites on which temperatures were relatively high had earlier and more concentrated germination than was found in shaded situations. Moisture deficiency below 32% by volume reduced germination and below 12% virtually eliminated it. No germination occurred in tamarack seeds which were under water. The presence or absence of light and variations in pH within the usual natural range appeared to have no significant effect upon germination. Tamarack reproduction has been found on sites having a pH range from 4½ to 7½.

The most satisfactory ground cover for good germination is the fine non-Sphagnum mosses. On Sphagnum, competition may be severe and germination frequently is not satisfactory. An insignificant quantity of seeds, if any, lay over in the duff to germinate the second year following dissemination.

No seedlings over six years of age were found in well-stocked existing tamarack stands. This is undoubtedly the result of the intolerance of the species. Immediately following germination, damping-off caused significant mortality. Submergence of succulent seedlings by flooding for a one week period killed them. During the latter part of the first summer, drought was a serious cause of mortality. However, the mortality

caused by drowning and by drought may be greatly reduced if light conditions are favorable. Seedlings grown in full light withstood reductions in moisture levels in the surface inch to less than one-half the level at which the mortality occurred in shade grown seedlings. Also, seedlings grown in full light withstood a longer period of flooding than those grown under overhead shade, a period perhaps three times as long.

In a study of cut-over black spruce types, data on the influence of cover upon regeneration in tamarack were obtained by Robert E. Buckman. The results are indicated in the following table:

Number of stems of tamarack reproduction per acre in relation to amount of overhead shade, density of brush cover, and heaviness of slash at time of cutting

	Overhead Shade	Brush	Slash
Open	261	92	213
Light (0% to 30%)	99	275	95
Medium (30% to 70%)	16	93	58
Heavy (70% to 100%)	0	51	10

Information on the growth of tamarack is extremely limited. Several reputable silviculturists in the Lake States are of the opinion that it is the fastest growing conifer in the East when placed upon favorable sites. In the forest survey undertaken by the Lake States Forest Experiment Station, growth data indicate that in six cord stands on average sites, a growth of ¼ cord per acre per year is not unreasonable. On similar sites, 10 cord stands may grow .4 per cord per acre annually. The volume growth of upland stands would undoubtedly be much better. On upland sites, 1½ to 2 feet of height growth per year is common, and diameter growth of .20 to .35 inches is to be expected in average years. Diameter growth on typical swamp sites varies in average over a 10 year period from about .06 to .20 inches annually, and is greatly influenced by the presence of the sawfly and by flooding. In many stands increment borings reflect the slow growth resulting from defoliation by the sawfly between about 1908 and 1916 and in the 1880's. Also, the dry 1930's often show a considerably better than average rate of growth in swamp tamarack.

Management directed toward getting natural regeneration must provide an abundance of sunlight to: (1) furnish temperature conditions suitable for rapid and complete germination; (2) reduce mortality caused by damping-off organisms; (3) provide earlier resistance to drought and flooding; and (4) increase rate of growth of the seedlings for earlier establishment. Cutting practices must also be such as will provide a suitable seed source. This is most satisfactory if dominant and co-dominant trees with well-developed crowns are available, if 50 to 150 year old trees are in the area, and if the seed source is not more distant than two times tree height. Reasonably consistent water levels are very desirable where they can be maintained to reduce drought and flooding losses, the two most significant direct causes of seedling mortality.

To get reproduction, clearcutting in progressive strips is recommended. These strips should not exceed two chains in width and may be placed at intervals such, that by the time the fifth or sixth strip is cut, the first cutting will be of an age to permit it to reseed the most recently cut strip. Alternative cutting methods which may prove satisfactory if the seasons immediately following cutting are not adverse to seedling survival include: (1) clearcutting following the establishment of an abundant crop of first year seedlings; or (2) clearcutting immediately following a bumper seed crop. Since good seed crops occur only once every four years or so, cutting in a particular area cannot take place annually under the latter two systems of management.

In cooperation with the Minnesota State Division of Forestry, a replicated experimental reproduction cutting study is being undertaken in which 50% of the stand is being removed in alternate strips, one chain in width. Slash disposal by piling and burning is being compared with no slash disposal, and commercial clearcutting to a 4 inch limit is being compared with complete clearcutting. Experimental cuttings are also being directed toward determining the efficacy of clearcutting over first year seedlings and following a good seed year.

THE CHEMICAL UTILIZATION OF TAMARACK

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The utilization of tamarack in the form of lumber, fence posts, mine timbers and logging, poles, and other uses which depend primarily on its physical properties and durability, has been discussed by other members of this meeting. It is the intent of the present discussion to consider the utilization of tamarack through chemical conversion.

Wood in general when considered as a chemical raw material consists of three principal components: a) Carbohydrate, the major part of which appears as cellulose, b) Lignin, and c) extractives such as resins, tannins, sugars, and other soluble material. Of these, cellulose in the form of wood pulp is at present of the greatest commercial importance, and it is the pulp and paper industry which is the principal consumer of wood as a raw material for chemical processing. Lignin appears primarily as a by-product of this industry and its commercial importance is relatively minor if one considers the amount used in comparison with the quantities produced. Aside from the pulp industry, there is an extensive record of research in the utilization of wood as a chemical raw material from which has arisen a variety of potentially valuable products. One factor, however, appears to be common throughout the study of chemical utilization of wood; that of economic development. A balance must be maintained between the cost of production and the competitive market price of the product. This problem appears to be a most difficult one of solution.

Where then does the Lake States' tamarack fit into this branch of utilization? There have been essentially no reported studies of the chemical utilization of this species other than its usefulness in the pulp and paper industry, and the use of tamarack as pulpwood may be summarized in comparison

with aspen and jack pine in the following table.

TABLE I

Pulpwood Volume on Commercial Land in Minnesota (1950)[1]

Pulpwood Consumed in Cords

	Total 1950	1948	1949	1950	% Consumed 1950
Aspen	10,400,000	263,726	143,816	266,796	2.56
Jack pine	3,500,000	186,641	110,541	177,456	5.08
Tamarack	2,400,000	3,516	1,435	941	0.039

It is quite obvious from these data that tamarack is not being used to the fullest extent by comparison with the other species listed, and the question of why it is not being used to a greater extent might logically be the central theme of this discussion.

Since jack pine, from the above table, appears to be in a favored position so far as the amount used in comparison with the amount available is concerned, it might be informative to compare the properites of jack pine with those of tamarack. Several of these properties, which must be taken into consideration in assuming the value of a species for use as pulpwood are listed in table II.

TABLE II

Results of Pulping by the Sulfate Process[2]

	Tamarack	Jack pine
Density lbs./cu. ft.	31	24
Yield screened pulp % of dry wood	40%	51%
lb./cu. ft. dry wood	12.4	12.3
Bleach requirement (single stage)	25 - 30%	20%

Although the greater density of tamarack would lead one to expect a greater weight yield of pulp, the lower percentage yield in comparison with that of jack pine appears to discount this advantage. In general, however, the two species appear to be almost equivalent. In addition, a recent communication from the Forest Products Laboratory has indicated that tamarack sulfate pulp has a normal cooking chemical requirement in a multistage bleaching process. Although the bursting strength, tensile strength, and folding resistance were reported as being lower, the tearing resistance was much higher than that of similar pulps from other Minnesota soft wood species. It has been suggested by the Forest Products Laboratory that: "The high tearing resistance of tamarack pulp is a feature which could be of great interest to northern sulfate pulp producers because of the recognized deficiency of their product in comparison with southern pine pulp."

1/ From Forest Resource Report No. 1 (1950) Lake States Forest Experiment Station.

2/ The comparisons are only approximate since published date for direct comparison are not available. (Data of Forest Products Laboratory, Madison, Wisconsin)

From the laboratory standpoint, the pulping properties of tamarack appear to be promising. What then is the feeling of the industry when asked for an opinion on the question of limited use of tamarack as a pulp wood? Such an opinion was sought from three of the major pulp mills in the Lake States, and one organization in Canada, and the response may be organized as follows:

1. The fact that most of the available tamarack is small second growth material as a result of larch sawfly damage is not a serious factor so long as the minimum of four inch top diameter for pulpwood is recognized, and wood operations conducted accordingly. Potential future damage by sawfly is a factor to be taken into consideration.

2. Tamarack can and has been satisfactorily pulped by the normal sulfate process. The resulting pulp is reported to be of low strength and brightness, but with sufficient study, the latter objection may be overcome to permit the production of high grade pulp. The overall properties of the pulp as reported, however, do not appear to be as good as those of pulps from jack pine and other species.

3. The fact that tamarack is a swamp species should not present additional difficulty in making the material available to pulp mills.

What appears to the speaker to be a most pertinent comment on the problem under discussion was that expressed by one of the individuals from whom information was sought. The belief was expressed that the use of tamarack as a pulpwood is a matter of economics, particularly with respect to its availability as a steady source of supply. "Since the competitive woods, such as jack pine, balsam, and poplar have been in ample supply, there has been no demand on the industry to go ahead with any program of utilization of this species." In other words, the responsibility for the more complete utilization of tamarack as a pulping species appears to be placed with the producer, and as a corrolary to this responsibility the question might be raised by the industry as to whether there is enough tamarack, present and future, to warrant the inclusion of this material as an established item of pulp wood inventory.

To summarize, tamarack compares favorably with other species presently used in the Lake States as pulp wood for the sulfate pulping process. Although the resulting pulp is reported to be slightly deficient in some of its strength properties, it excells in its tear strength, a factor which might overshadow its deficiencies. Although tamarack is of high density, the lower pulp yield appears to discount any advantage which would be anticipated in the purchase of pulp wood on a volume basis; an indication which must be further substantiated bedore judgement is passed. Pulp mills are aware of tamarack as a pulpwood species and have used it in the past with satisfactory results, and they are open minded about its continued use if it can be made economically available to them.

Tamarack is known to have been pulped by the sulfite process, and to be used as pulpwood for the manufacture of insulation board. However, in the absence of published data, discussion of these subjects would not be practical.

APPRAISAL SURVEYS AND AERIAL SPRAYING

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Appraisal Surveys

The current larch sawfly infestation was reported as early as 1940 by the Minnesota detection survey (Hodson, 1940)1/. Subsequent annual detection survey reports charted its build-up, until by 1949 the epidemic was of proportions sufficiently large to warrant exploratory appraisal surveys. These were carried out in the summer of 1949 under the direction of the Forest Insect Laboratory of the U. S. Department of Agriculture, located at Milwaukee, Wisconsin, and have been continued through 1951 in somewhat modified form.

The survey procedure in 1949 consisted of sketching in larch sawfly defoliation levels during aerial reconnaissance flights made at altitudes of 800-1,000 feet above the ground. This same procedure was followed in 1950, augmented by ground observations obtained from permanent plots.

There was little apparent difference in extent or intensity of the epidemic in 1950 over 1949. Very heavy rainfall during early July seems to have resulted in drowning of much of the larval population on the Chippewa National Forest in 1949, but the situation throughout the remainder of the infested area did not materially change through 1950.

The following Table I indicates the level of infestation in 1950. Zone I refers to tamarack acreage where average defoliation per tree was in excess of 50%. Zone 2 represents the acreage of tamarack that was defoliated in excess of 50% in 1949, but which sustained less than 15% average defoliation in 1950. Zone 3 represents tamarack acreage that was defoliated less than 15% in 1949 and 1950.

Cunningham, et al (1950)2/ indicate that Minnesota possesses some one million acres of tamarack type. The fact that some 390,604 acres of this total lay within the area of infestation in 1950 demonstrates the seriousness of the problem.

The Division of Forest Insect Investigations of the U. S. Department of Agriculture carried out an aerial reconnaissance of tamarack in Northern Minnesota again in 1951, in cooperation with the Office of the State Entomologist, Minnesota Department of Agriculture, Dairy and Food. The technique used in the 1951 survey differed considerably from the methods used in 1949 and 1950. In the latter two years, flight lines were planned with emphasis on reconnoitering the larger areas of tamarack type. In 1951, the Beltsville laboratory of the U. S. Department of Agriculture made an operation-recorder equipped plane available to the project, which permitted rapid transcription of the observations and also made possible fuller coverage of the forested area. Continuous flight lines were flown east to west and west to east at 12 mile north-south intervals. Continuous records were taken of tamarack defoliation using three arbitrary defoliation levels, eg., no defoliation, partial defoliation, and complete defoliation.

1/ Hodson, A. C., 1940. Minnesota Forest Insect and Disease Survey for 1940. Mimeo. Minn. State Dept. of Conservation.

2/ Cunningham, R. N., et. al. Forest Resources of the Lake States Region. Forest Research Report #1, Forest Service, U. S. Department of Agriculture.

TABLE I

Tamarack Type and Larch Sawfly Infested Areas on the Chippewa and Superior National Forests and Adjacent Lands - 1950

County	Total Acreage of Tamarack Type	Estimated Acreage of Tamarack Type 1/ in Infestation Zones (See Text): Defoliation 50% or Over	Defoliation Over 50% 1949 Under 15% 1950	Defoliation Under 15% 1949 and 1950
Lake of the Woods	62,000	62,000	-	-
Koochiching	148,000	112,480	35,520	-
Clearwater	9,100	-	-	9,100
Beltrami	54,000	22,140	21,600	10,260
Hubbard	5,000	-	-	-
Wadena	2,000	-	-	-
Cass	31,900	-	11,484	8,932
Crow Wing	10,400	-	-	1,872
Aitkin	39,400	-	-	23,246
Itasca	29,000	-	17,980	11,020
Carlton	3,500	-	-	3,150
Lake and St. Louis	39,731	27,812	-	11,919
Cook	89	89	-	-
Totals	434,120	224,521	86,584	79,499

Using this strip sampling technique, it was possible to map in the infestation in 1951 with more accuracy. The levels of defoliation and infested acreage are presented in a special report (Eaton, et al, 1952) 2/ The following infestation figures (Table II) are taken from this report.

TABLE II

Estimated Acreages in Each Defoliation Zone in Larch Sawfly Infested Tamarack Type in Northern Minnesota Counties - 1951

County	Total Acreage of Tamarack Type	Defoliation: Complete	Partial	None
Aitkin	39,400	-	-	39,400
Beltrami	64,400	3,864	41,860	18,676
Carlton	3,500	-	-	3,500
Cass	39,100	-	4,888	34,212
Cook	89	11	78	-
Crow Wing	10,400	-	-	10,400
Itasca	38,600	-	17,756	20,844
Koochiching	148,000	18,500	122,100	7,400
Lake and St. Louis	39,731	14,303	21,653	3,775
Lake of the Woods	62,000	31,000	31,000	-
Roseau	17,300	692	3,806	12,802
Totals	462,520	68,370	243,141	151,009

1/ The "Tamarack type" designation is used as established by the United States Forest Service T. M. Handbook for the North Central Region (1949); and refers to that tamarack occurring in stands containing 50% swamp conifers with tamarack outweighing other species.

2/ Eaton, Charles B., James W. Butcher, and R. C. Heller, 1952. The Larch Sawfly in the Lake States With Special Reference to Minn. - 1951 Season - Reconnaissance Survey. Forest Insect Lab., Milwaukee, Wisconsin, June 9.

In both 1950 and 1951 better than 300,000 acres of tamarack were undergoing attack by the larch sawfly. The partial defoliation category in 1951 includes both the 50% and over, and the less than 15% categories that were used in the 1950 survey (Table I). The refinements in technique introduced in 1951 resulted in better differentiation of areas of little and no defoliation, and caused the apparent increase in acreage shown in the column headed "Defoliation - none." This does not indicate a lessening of the acreage infested. It can be seen, however, that almost one-third of the total tamarack acreage in the state is under attack.

Several of the obstacles to continued appraisal surveys of forest insect outbreaks are the time and expense involved. The operation recorder aerial reconnaissance technique has the advantage of speed and economy, making possible rapid efficient surveys of infestations which have symptoms that are visible from the air. It is calculated that the 1951 larch sawfly survey was carried out at a total cost of 11½ cents per thousand acres.1/

Experimental Chemical Control

Control of insect infestations by the use of insecticides has become more and more practicable in recent years, with the widespread use of contact insecticides and improvements in aerial application equipment and techniques. Where the insect life history is such that most or all of the population is accessible to the toxicant in a susceptible form, the problem is chiefly one of selecting the proper chemical and dosage. In the case of the larch sawfly, however, almost any spray application will find some portion of the sawfly population in the egg, larval, cocoon, or adult stage. Since only the larvae and possibly the adults can be assumed susceptible to the toxicant, the timing of a single spray application must, at best, be a compromise in which somewhat less than complete control can be expected.

Experimental control was attempted in 1950 in northern Minnesota, using DDT at the rate of one pound per gallon of fuel oil per acre of tamarack, applied by aircraft. One application was made at the time of peak adult activity on June 30, and the other, one week before the peak of larval feeding (when foliage consumption was at its peak). By this time, 10% to 20% of the 1950 larval population had cocooned in the soil beneath the trees. As a result, no more than 80% of the 1950 sawfly population could have been controlled, had 100% of those larvae still feeding been killed by the toxicant. (Butcher and Eaton, 1952).2/

Analysis of seasonal frass (excrement) volume subsequent to spraying based on comparison of sprayed and check areas, indicated that in the area where application was made at the peak of adult activity, only about 34.3% reduction in frass could be attributed to sawfly mortality as a result of spraying. Where the application was made a week before the peak of larval feeding, larval population reduction appeared to be on the order of 77.3% in the sprayed plots. Since the larval population represented at best 80% to 90% of the 1950 sawfly population, over-all population reduction was on the order of 62% to 70% as a consequence of spraying. It may prove that a population reduction of this size is adequate, in combination with natural mortality factors, to prevent heavy defoliation of tamarack the year following application of chemicals.

1/ Inter-office Correspondence, June 27, 1952; H. J. MacAloney, Survey Leader, Division of Forest Insect Investigations, U. S. Department of Agriculture, to Milwaukee Forest Insect Laboratory, U. S. Department of Agriculture.

2/ Butcher, James W., and C. B. Eaton, 1952. The Larch Sawfly Epidemic in the Lake States Through 1950. With Notes on Experimental Spraying. U. S. Bur. Ent. and Plant Quar. (E series in press.)

This is in the realm of speculation however, and remains to be demonstrated.

In conclusion, it seems wise to continue cooperative survey programs in order to determine the extent and intensity of sawfly depredations. In addition, complete and accurate records are necessary to prevent misconstruing tamarack mortality which may be due to phenomena other than larch sawfly attack; eg., drouth or flooding. Aerial spraying offers a means of preventing mortality to high value stands where mortality is imminent, if the sawfly pressure is relieved. In such situations, there may be a definite place for chemical control, but the spread of developmental stages and the scattered nature of tamarack occurrence preclude its general application to this problem. This is certainly true if only one application is considered desirable.

PROBLEMS INVOLVED IN COOPERATIVE SPRAYING AGREEMENTS

Charles B. Eaton, Entomologist in Charge
Forest Insect Laboratory
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United States Department of Agriculture

The suppression or control of forest insect epidemics presents many aspects that are akin to the control of forest fires. It presents other aspects that are quite drastically different, and by comparison, make the control of fires seem quite a simple matter. Like fires, our forest insect pests, in their struggle for existence respect neither persons nor property lines. They attack the developing, or mature, timber crops of private and public owner alike. In some parts of the country -- not necessarily in the Lake States -- it might even be said that insects cause more damage to public forests than to private forests. In some instances, there are good reasons why this is true, but over-all the effect is probably more apparent than real.

The development of a forest insect outbreak and a mounting toll of damage may indicate a need for a control program which would involve spraying on a forest wide basis. The job of getting such a program under-way and bringing its execution to a successful conclusion is not as simple as it might seem, accustomed as we are to thinking in terms of spraying to control pests of agricultural crops. Assuming that we are confronted with the prospect of taking action against a specific forest insect pest, such as the larch sawfly, and assuming that we are reasonably well satisfied with the promise of success in controlling this pest that the use of insecticides may hold, what are some of the difficulties that may be met in setting in motion the wheels of a cooperative control project? Let us examine this question briefly. In seeking answers, we have access to the experience of those who have been engaged in several extensive cooperative forest insect projects in the western part of the country, about which I am sure many of you have heard, through the press, through technical reports, or from other sources. I refer to the tussock moth control project in Idaho in 1947, and to the spruce budworm control projects in Oregon and Washington in 1949, 1950, and 1951. Closer to home we can draw upon experience right here in the state of Minnesota in a cooperative project undertaken about a year ago to combat the forest tent caterpillar in forest areas near Leech Lake.

Perhaps the greatest single problem in cooperative forest insect programs is the great diversity of land ownership. It is not only the diversity in classes of ownership which complicates matters, but within the classes the great diversity of individuals and agencies who are concerned for one reason or another with the protection of the resource. In mentioning this subject, I do not by any means intend to imply that there should be a consolidation of all our forest resources under one ownership. It is simply a situation with which we have to deal; a very realistic one, I should add, and one that gives rise to

many of the problems encountered in large scale control programs.

In any cooperative forest insect control program, it is of course desirable, if not necessary, to have at the outset, general agreement among those concerned that the problem is of some consequence, and that the situation is serious enough to warrant the expenditure of funds required to correct it. In this part of the country, those organizations or agencies concerned might be said to be quite fairly represented by the gathering we have here today to review this larch sawfly situation. The breakdown would be about as follows:

1. Land managing agencies - concerned with management of the forest resources.

    a. Private owners and operators
    b. State foresters - Conservation Department
    c. Federal foresters - Forest Service, Indian Service

2. Technical advisers - responsible for surveys and providing technical knowledge in control.

    a. State entomologists
    b. Federal entomologists

The pros and cons on the need for control may be weighed, and sentiment for or against action may be moulded by a comparatively large group such as we have here today. However, once a decision for action is reached, a control undertaking can best be developed by a comparatively small working committee representing public agencies and private industry. Where more than one or two private concerns are involved, industry can best be represented on such a committee by an individual chosen by and authorized to speak for the group he represents. To some extent the same may be said for representation from public agencies. In order to function most effectively, a small committee made up of individuals empowered to act for the agencies they represent is usually far more satisfactory than a larger one.

Before reaching the committee state, in fact even before a decision to conduct control work is reached, one question is certain to come up that I have not as yet touched upon. I refer to the matter of financing. The enabling legislation by which the federal agencies participating in cooperative forest pest control are authorized to act, is the Forest Pest Control Act of 1947. I intend to discuss this Act to some extent later on; however, for the moment I would like to bring out one point about this piece of legislation. This is the fact that the Forest Pest Control Act does not call for matching funds, and prescribes no ratio for federal to other funds, under which monies made available under the Act must be spent. On each individual control project completed to date, the apportionment of costs has been decided on the special circumstances of the case. The law stipulates that no funds appropriated under the Act can be used on cooperative control work until such contributions as the Secretary of Agriculture may require have been made or agreed upon. How this has worked out I can perhaps best illustrate by citing the western work in controlling the spruce budworm. The apportionment of the costs among various land owners on this project has been as follows:

1. Federal government - 100% of the cost of treatment on federal lands, and 25% of the cost of treatment on private lands

2. States of Oregon and Washington - 100% of the cost of treatment on state and county lands, and 50% of the cost of treatment on private

lands

3. Private landwoners - 25% of the cost of treatment on their holdings

In the tussock moth control project in Idaho in 1947, a slightly different apportionment of costs was made in which the federal government bore some share of the cost of control on state lands as well as on private lands. The forest tent caterpillar spraying operation here in Minnesota last spring, is the only undertaking in the east bearing any semblance of similarity to these larger projects. In the forest tent caterpillar work, each landowner provided 100% of the cost of treatment of his holdings. As control projects have come along during the last 3 or 4 years, there has been a trend in the financing toward apportioning costs so that each management agency bears a share that is commensurate with the benefits each is likely to get from the work. It seems likely that this trend will continue.

Once the problem of financing control operations has been given due consideration, it should become evident if the control work is economically justifiable and economically feasible. One measure of this is the interest and willingness of the individual owner to furnish funds necessary for work on his own land. There is very little likelihood that public agencies will undertake control work on mixed classes of ownership if private industry shows no interest in supporting and participating in the job. It is unfortunate, but true, that even with an urgent need and a cash-on-the-barrel-head interest on the part of industry in favor of control work, public agencies must often wait on the appropriation of funds by legislative bodies before being able to make definite commitments. These obstacles notwithstanding, it has been the practice to prepare plans for forest insect control work on these cooperative ventures, contingent upon funds being made available in time for use.

The preparation of careful plans for forest insect control work well in advance of their execution is a matter that I cannot emphasize too strongly. It is in this phase of the work that the committee I mentioned earlier in this discussion can function most effectively. To be successful, control plans must be based on adequate surveys. The surveys should have preceded any consideration of the need for control, as I perhaps should have pointed out earlier. The essential preparatory measures are many and varied. Responsibility for the administrative phases of the control program must be fixed. Usually, this task devolves upon one of the land managing groups that is well equipped by nature of its organization, to administer the project. Occasionally, on exceptionally large jobs, the administrative work load may be divided between two or more agencies for the sake of expediency. Responsibility for the technical phases of control must be fixed, and it is here that the services of the entomologist are of value. The entomologists must supply the necessary knowledge required concerning the procurement of spray materials, their use, and their proper application against the insect, and measurement of their effectiveness.

The execution of a cooperative agreement between parties concerned is essential to set up authorities and responsibilities for various phases of control work. The most important items in these agreements are the designation of:

1. the agency responsible for conducting the control program

2. the agency responsible for entomological phases

3. responsibility for collection of funds from landowners

4. a general formula for sharing the costs among private landowners, state and federal agencies and

5. establishment of the method and rate of sale application.

Aside from these things, cooperative control programs involve a tremendous amount of detailed work which might be placed under the general heading of logistics. Maps of the areas to be treated must be prepared, with treatment units well enough defined on the map and on the ground so that the spray pilot can recognize them. It may be necessary to improve air strips, or build new ones before spraying operations can begin. Long ferry hauls consume great amounts of the limited time during which air conditions are suitable for spraying; thus it is most advantageous to have airports as close to the scene of operations as possible. Bids must be prepared and contracts awarded for aerial spraying services and for the procurement of insecticides. Performance checks on the equipment of successful bidders must be made before spraying is started. Provisions must be made for storing and handling the quantities of insecticide that the job requires, and arrangements must be provided for making the insecticide available where it is needed and when it is needed with a minimum of lost time. Since weather is a prime factor in the success or failure of aerial spray applications, provision must be made for local forecasting and the exercise of control dictated by weather changes as prescribed in the flying contract. Aside from these details, that are of a more or less technical nature peculiar to the operation, there may be the usual, but by no means small problems of providing for housing, food, transportation and communication units that are associated with the handling of a sizeable organization in woods jobs.

It might be thought that the work of the entomologist has ended once he has made recommendations on what should be done, and has assisted in the planning stages on the purely technical phases of the job. By technical phases I mean such things as prescribing specifications for insecticide materials to assure procurement of the proper chemical, outlining procedures for applying the insecticides in order to realize the best use of them, defining the types of equipment acceptable for spray application, and so on. Actually, this is but the beginning of the entomologist's job. Perhaps one of his most important tasks is that of determining when control work should commence. The timing of control work in relation to the development of the insect is extremely critical, and for many of our forest pests the period is so short (just a matter of two or three weeks) and within that period the number of hours for effective spraying is so limited, that every minute counts. In the same locality, the period for best results may vary from year to year, depending upon vagaries of environment. Through his observation on the development or habits of the insect at the scene of operations, the entomologist can pretty well define this period, and action can be taken accordingly. One other task for which the entomologist is responsible is that of checking the effectiveness of spray applications. Techniques for collecting spray samples may be used for this work or in some cases, the effects on the insects themselves may serve the purpose. In any event, it is important that some systematic method be used, in order that improperly treated areas, or those that are missed entirely, can be resprayed when possible. There are other more obvious capacities in which the entomologists can function effectively in the execution of control work, but I shall not dwell on this stage of the operation further.

There is one other aspect to cooperative spraying projects that I would like to touch upon briefly before leaving this topic. I have in mind the damage

claims that so often follow area-wide applications for DDT sprays. It is not unusual for a rash of complaints to develop in the wake of some of these undertakings, usually ranging from those totally incredible to perhaps a very small number within the realm of possibility. It has been the practice of the Federal government to stipulate in cooperative agreements or in spraying contracts that it disclaims any responsibility for public liabilities arising from the spray applications on state or private lands. In the work in the west against the spruce budworm, the state has undertaken to settle damage claims that have arisen following control operations. The great majority of these claims have been dropped at the request of the claimant following an investigation of the circumstances in each case. Some individuals cling to the belief that DDT applications cause havoc among fish and wildlife, but for the dosage commonly used in forest spraying, (1 pound DDT in 1 gallon of spray per acre) there is little basis in fact for this idea. A wealth of experience as well as considerable experimental work on this point do not show that the 1 pound dosage causes any injury of consequence to fish and wildlife in their natural habitat. High dosages, on the other hand, can be injurious. For this reason, if for no other, DDT and other new insecticides should be used under expert guidance and the dosage should be held at the minimum level necessary to effectively control the insect. Adherence to this principle should hold to the absolute minimum the number of authentic damage claims arising from forest insect control operations.

The Forest Pest Control Act

Let us turn now from the problems involved in cooperative spraying to consideration of the Forest Pest Control Act. You will recall that I mentioned the Act in commenting on the problem of financing joint pest control programs. The Forest Pest Control Act, Public Law 110, was enacted in 1947 by the 80th Congress. It was the natural outgrowth of wide-spread interest on the part of the public, and demand for assistance in coping with forest pest problems. With closer utilization and the change in our concept of values of the forest resource has come greater emphasis on the need for protection from losses from all sources.

The Forest Pest Control Act is the basis for the development of a coordinated program of forest pest control. It enables the Federal government to cooperate legally with state agencies and private industry in conducting surveys and taking action to control forest pests. As stated in the text of the Act, its primary purpose is "to protect, and preserve forest resources of the United States from the ravages of bark beetles, defoliators, blights, wilts, and other destructive forest insect pests and diseases". In order to accomplish this worthy objective, the Act vests in the Secretary of Agriculture the authority, either directly or in cooperation with Federal, state and private forestry agencies and owners, to

1. "conduct surveys on any forest lands to detect and appraise infestations of forest insect pests and tree diseases,

2. to determine the measures which should be applied on such lands to prevent, retard, control, suppress, or eradicate incipient, threatening, potential, or emergency outbreaks of such insect or disease pests, and

3. to plan, organize, direct, and carry out such measures as he may deem necessary to accomplish the objectives and purposes of this Act".

Obviously, this is a monumental task, and one that in my belief no single organization, public or private, regardless of its resources, could adequately

handle without the aid of everyone connected with the management, utilization and preservation of the forest resource. When you remember that there are over 460 million acres of forest land in this country to be kept under surveillance, it must become evident that the forest pest protection program must be founded upon cooperation. It is recognized, of course, that the entire 460 million acre area of forested land will not all require the same frequency and intensity of coverage. There will probably always be some forested areas that, because of their nature, will suffer more intensively from pests than will others. Acknowledgement of and allowance for this fact, however, will not reduce the job of carrying out a minimum program to the point where it can be done without the help of everyone having an interest in timber lands.

To the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, has been given the task of conducting forest insect surveys and recommending needs for control under the provisions of the Forest Pest Control Act. The Division of Forest Insect Investigations, represented in this region by our Milwaukee laboratory, has for many years borne the brunt of the forest insect research job and so-called service work throughout the country. Because the proper conduct of surveys and intelligent recommendations for control require technical knowledge concerning the insects themselves, as well as the trees upon which they feed, it is essential that trained forest entomologists handle or guide that work. Since its activities are national in scope, it does not appear illogical that the Bureau of Entomology and Plant Quarantine should provide technical leadership to all agencies concerned with forest pest protection work.

It is the conception of those of us in the Division of Forest Insect Investigation that forest insect survey and control needs for the country can best be taken care of by the development of a program of action for each region served by Division laboratories. The Milwaukee laboratory, for example, serves the nine north central states: North Dakota, Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Iowa and Missouri. Following the regional idea, a program of action is being developed to meet the needs of this territory. The basis for determining just what are the survey and control needs of the region is as follows:

1. timber-growing, recreational, watershed and other forest values;

2. the susceptibility of forests to attack by natural or introduced forest insect pests;

3. the availability of effective control methods, and

4. the expressed willingness of public and private forest managing agencies to cooperate in detecting and controlling outbreaks that seriously threaten to damage or destroy the forest resources.

The essential responsibilities of the Division of Forest Insect Investigations under the provisions of the Forest Pest Control Act, reduced to the simplest terms are to

1. conduct surveys

2. determine the entomological soundness of control, and

3. furnish public and private forest owners and managers with technical assistance in carrying out control programs.

In the case of control projects financed wholly or in part by Forest Pest Control Act funds, this service is mandatory. As funds have become available, starting in 1949, work has been developed along these lines. Concurrently, funds have been allotted to control insect outbreaks on a number of cooperative control projects.

Perhaps some of you are wondering how operations under the Forest Pest Control Act have worked out, what weaknesses have developed in the light of experience, why some sort of a formula or fixed basis for matching funds has not been prescribed, and particularly, what, if anything, has this part of the country gained as a result of having this piece of legislation on the books. The record of three years of work on surveys and control under the Act speaks for itself. In most cases it has worked very well where there has been a need for joint action. There has not been the occasion in the eastern part of the country for the extensive control undertakings that have been carried on in the west, but there has been ample opportunity to demonstrate the usefulness of the law.

The inability of the Federal government to commit itself to financing its share of control work until funds have actually been appropriated under the Act has proven to be a distinct disadvantage. Especially has this been true where authorization for expenditures has been delayed until it was time or past time to most effectively conduct the work. It has been necessary on a number of projects to go ahead with plans and take every step short of the actual obligation of the Federal share of the funds, on the assumption that appropriations for the project would be forthcoming. This can be a frustrating experience to say the least. Certainly, it is not the sort of thing that is calculated to build confidence among cooperators. One way in which this difficulty can be avoided is through the establishment of a contingency fund to be drawn upon when necessary. In fact, it may well be that all control appropriations could best be handled by a contingency fund. At the present time, budgetary requirements call for control estimates so far in advance that the estimate cannot be said to fairly represent what actually may be required as a result of future developments.

The Forest Pest Control Act has been subject to some criticism because it fails to provide a formula for apportioning the cost of control among Federal, state, and private agencies on joint control operations. Omission of specific language on this point was not by any means the result of an oversight in drafting the bill. The Forest Pest Control Act was purposely set up to provide a very flexible basis so that almost any formula could be adopted for a given project so long as it was considered equitable and advantageous to the government by the Secretary of Agriculture. It may well be that for many control projects, some basic formula would be desirable. If specified in the Act, however, such a formula could have the effect of ham-stringing or preventing action in certain cases where the control needs might be urgent, but where the dictates of the formula could not be met. As I mentioned earlier, the trend in applying the Act has been toward placing upon the individuals or agencies that benefit the most, the burden of the cost of control.

The principal effect of the Forest Pest Control Act in this region has been furthering the development of forest pest surveys, and to a lesser extent, in providing measures for pest control work on public lands. There has not as yet developed here a need of any forest-wide insect control program that can be considered economically justifiable. Some progress is being made in cooperative surveys and in coordinating survey activities in this region. The larch sawfly survey completed jointly by the Minnesota State Entomolo-

gist's Office, and the Milwaukee Laboratory this last season, is an example of developments along this line. Somewhat similar cooperative activities are in progress in other parts of the region.

In concluding this discussion, I would like to leave with you this one thought. It is the conviction of forest entomologists that a sound forest pest control plan must be founded upon basic research, adequate surveys, and properly executed control programs. This has been the central theme of the work conducted in this country during the past half century, and to it we owe most of our knowledge of forest insects in this country today. The Forest Pest Control Act of 1947 provides means for surveys and control; however it makes no provision for research that is direly needed in order to develop successful preventive or suppressive practices.

BIOLOGICAL AND CULTURAL PRACTICES FOR CONTROL OF THE LARCH SAWFLY

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Winnepeg, Manitoba

As opposed to chemical or artificial control, biological and cultural controls may be conveniently considered together under the term natural control. The biological control complex of the larch sawfly is composed of parasites, predators, and diseases. Cultural practices include operations that alter the habitat to render it less favorable for the insect's development or more favorable for natural enemies, controlling by utilization the distribution of age-classes of tamarack, and preventing the accumulation of extensive areas of mature and overmature stands.

In most of Canada and probably over most of its range in the United States, a characteristic of the parasite complex of the larch sawfly is that it is composed of only three major species, Mesoleius tenthredinis Morley, Bessa harveyi (T.T.), and Tritneptis klugii (Ratz.). These species may compete with each other. The first two species attack the larval stage of the sawfly, and the last attacks the cocoon stage. M. tenthredinis was deliberately introduced from Europe. Evidently it was an effective control factor in North America at one time. However, evidence has been obtained in Manitoba and Saskatchewan that the sawfly has developed an immunity to this parasite and it is improbable that it will regain its pre-eminent position in this region. Probably a similar immunity would be found to exist in the Lake States and Eastern Canada. The parasitic fly, B. harveyi (T.T.) has proved more effective than M. tenthredinis in the Prairie Provinces during the current outbreak, which began about 1939. At times more than 45% of the sawflies sampled were parasitized by this species. There are a number of limitations to its effectiveness however. It is an inefficient parasite in many respects, and in infested areas its population builds up slowly. T. klugii is a small chalcid that has reappeared recently in several areas and is being recovered in increasing numbers from several points in Manitoba and Saskatchewan. Its habits suggest that it may have difficulty in surviving through periods when the density of the host population is low. Results of observations and investigations indicate that B. harveyi and T. klugii might prove more useful if mass releases were made in the early stage of an outbreak.

Predators of the larch sawfly include mice and shrews, insects, and birds. Mice and shrews, which feed on cocoons in the ground, have on occasion almost exterminated the larch sawfly in some stands. They can be effective predators in well-drained sites that favor the nesting of small mammals. Wireworm larvae also destroy a number of cocoons. Nymphs of a stink bug, Podisus sp., have been observed feeding on eggs and larvae of the larch sawfly and their value may be greater than is suspected. No evidence of extensive destruction of sawfly larvae by birds has been obtained, but more intensive study and observation are needed.

Diseases of the larch sawfly are being investigated at the Laboratory of Insect Pathology and the Forest Insect Laboratory in Sault Ste. Marie, Ontario.1/ There is no evidence as yet of a virus disease in the larch sawfly. A considerable number of species of bacteria have been isolated from dead sawflies collected in the field, and their importance is being investigated. One species has produced significant mortality of larvae in field trials, but incidence of occurrence in nature in the areas investigated is low.2/ Representatives of several genera of fungi have also been recovered from dead larvae and pupae. Under laboratory conditions, high mortality of the larch sawfly can be induced by certain fungi, but attempts to establish epidemics in the field have not been encouraging. These studies emphasize the need for more fundamental studies of the physiology and parasite-host relationships of fungi and bacteria.

Possibilities of control by cultural and management practices appear limited, but at least they offer scope for immediate effective action. The history of larch sawfly outbreaks on this continent indicates that severe losses are sustained when there are extensive areas of mature and overmature tamarack. It seems important therefore, to bring about a more even distribution of age-classes and to utilize tamarack promptly when it reaches merchantable size.

If conditions in the Lake States correspond to those in the Boreal Forest in Canada, it is probable that a great proportion of existing stands fall into roughly one age group. If efforts are begun now to re-distribute age-classes by the gradual utilization of existing stands, several benefits can be expected to follow. Some of the tamarack that might be killed during the present outbreak would be utilized. It would prevent the accumulation of extensive areas of overmature tamarack. Finally, as age-classes become more evenly distributed, there would be a steady, constant supply of tamarack reaching merchantable size. Under present conditions, there are alternating periods of abundance and scarcity. Furthermore, we can expect that periods when mature tamarack is abundant will be accompanied by severe sawfly outbreaks and acute salvage problems.

The study of cultural practices that might be used to produce a less favorable habitat for the insect is largely in the experimental stage. They have not been evaluated under field conditions. In the annual life-cycle of the insect, about nine to ten months is spent in the cocoon stage in the soil. In this stage, the insects may succumb to several mortality factors associated with extremely wet sites, and probably with extremely dry sites. Sawflies in cocoons may be killed by flooding for a relatively

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1/ Personal communication - Laboratory of Insect Pathology, December 7, 1950.

2/ Personal communication - Forest Insect Laboratory, January 16, 1952.

short time during the period of spring development when larvae are changing to adults, or just after most of the new cocoons have been formed in late July and early August. Under certain conditions, where water levels can be regulated, flooding might prove an effective means of control. Not much is known about dry-site relationships, but it is probable that sites of this type would favor intensified activity by parasites and predators.

At this conference, three main types of control have been considered; biological, cultural, and chemical. It can be expected that eventually each will find its proper place in a permanent program for control of the larch sawfly. Biological and cultural methods offer prospects of partial control, and, under favorable circumstances, possibly economic control. Though results to date have not been spectacularly successful, future developments may permit more effective use to be made of natural enemies, which include parasites, predators, and disease. Much remains to be done in exploring cultural and management practices. It is not too optimistic to expect that if the urgency of the situation increases, means will be found to utilize tamarack in such a way that losses caused by the larch sawfly can be reduced. The use of chemicals will no doubt prove important and valuable where the cost is justified to prevent or control infestations in valuable stands, to prevent the loss of timber in stands in imminent danger of heavy tree mortality, and possibly to arrest the development of incipient infestations.

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SUMMARY

The larch sawfly conference was held in order to answer, or shed light on the following aspects of Minnesota's tamarack resources:

1. Availability: Current and potential.

2. Markets: Current and potential.

3. Consumption: Current and potential.

4. Utilization: Current and potential.

5. Management: Current and potential.

6. Larch sawfly: Damage surveys; chemical and biological control.

The following brief summary of contributions to the conference analyzes the extent to which the foregoing problems were resolved.

1. Lake States and Minnesota tamarack supplies can be broken down as follows:

	Acres	
	Lake States	Minnesota
Sawtimber	30,000	20,000
Poles	300,000	150,000
Seedlings and saplings	440,000	270,000
Poorly stocked	830,000	500,000
Totals	1,600,000	940,000

2. The potential supply of tamarack is much greater than present volume because so much of the area is now in relatively small sizes. For example, there is a strong demand for mine timbers which cannot be filled with present small sized sticks.

3. Current demand for tamarack is light, varying from 2,000 to 20,000 cords annually; but market for pulpwood, mine timbers, railroad ties, piling, utility poles, etc. would be strong in approximately ten years if stands can be preserved. Demand for this species, which can be pulped commercially by the sulphate process, is now, and would probably be greater in out-of-state mills which do not have access to pine available in Minnesota.

4. While information on tamarack growth is limited, there is evidence that this species is the fastest growing conifer in the Lake States, when established on favorable sites. Reproduction can be encouraged by clear cutting in progressive two-chain strips, or by cutting immediately after a bumper seed crop or establishment of first year seedlings.

5. There is evidence that emergency chemical spraying can alleviate the sawfly threat to high value, productive tamarack stands where the existence of substantial values can be established. The manifold problems inherent in such operations, where more than one

ownership is involved, and where joint action by several groups is necessary, emphasizes the importance of thorough preliminary organization of such projects.

6. The difficulties incident to chemical control for the larch sawfly highlight the importance of continuing to experiment with parasite releases and redistribution of age-classes through cutting. This latter condition is desirable not only as a means of reducing the size of sawfly epidemics and minimizing apparent increased susceptibility in older stands, but also to preserve tamarack markets at a fairly constant level.

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APPENDIX

List of Those in Attendance at
Larch Sawfly Conference
February 7, 1952

NAME	AFFILIATION	ADDRESS
Aamodt, T. L.	Office of State Entomologist	301 Coffey Hall, University Farm, St. Paul 1, Minnesota
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Adams, Earl J.	Minnesota Forest Service	St. Paul, Minnesota
Argetsinger, L. M.	Kimberly-Clark Corporation	Neenah, Wisconsin
Banan, Ch. H.	Iranian Forest Service	Teheran (Iran)
Beatty, L. R.	St. Louis County	Duluth, Minnesota
Benjamin, Daniel M.	Forest Insect Laboratory	Milwaukee, Wisconsin
Berklund, B. L.	Nekoosa-Edwards Paper Co.	Port Edwards, Wisconsin
Brener, W. H.	Wisconsin Department of Conservation	Wisconsin Rapids, Wisconsin
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